Negative psychological experiences and saliva secretory immunoglobulin A in field hockey players

Running head: SIgA and negative psychological experiences

Abstract

Understanding psychological factors that affect immunity in sport might help to reduce infection risk in athletes. The present study examined within-person changes and individual differences in perceived coach control, intentions to drop-out, and saliva secretory immunoglobulin A (SIgA). Thirty-two field hockey players completed questionnaires and provided saliva samples over a two-month period. Within-person increases in individuals' perceptions of psychological control and intentions to drop out were positively associated with SIgA concentration. Individual differences in control or drop out intentions were not associated with SIgA. Interventions in athletes to prevent immune disturbances and reduce infection should consider these psychological factors.

Negative psychological experiences and saliva secretory immunoglobulin A in field hockey players

Some athletes report an increased incidence of upper respiratory tract infections (URTI) during training regimens (Neville, Molloy, Brooks, Speedy, & Atkinson, 2006). Indeed, URTI have been reported to be the most common health complaint among elite sports men and women at a major sporting event (Robinson & Milne, 2002) and have been reported to account for 61% of missed training days in elite yachtsmen over a two-year training period (Neville et al., 2006). It is thought that individuals who appear more susceptible to infection exhibit a range of physiological and psychological differences compared to those who remain healthy (Gleeson & Bishop, 2013; Meeusen et al., 2013). Although the immunological mechanisms underlying this increased incidence of infection are not fully understood, levels of saliva secretory immunoglobulin A (SIgA), an antibody present in mucosal secretions, have been shown to be decreased in some athletes during periods of intensive training who report increased incidence of URTI (Fahlman & Engels, 2005; Strugnell & Wijburg, 2010; Gleeson & Bishop, 2013). In order to provide efficacious and targeted health interventions to counteract illness, it is important to understand why certain individuals are at particular risk of infection within athletic settings. Considering the broad influence of psychosocial factors on immune function (Valdimarsdottir & Stone, 1997), the present study examined whether perceived interpersonal control and intentions to quit sport are associated with altered levels of SIgA in saliva. The present results also add to the existing literature by disaggregating within- and between-person relationships (Curran & Bauer, 2011) in a sample of sub-elite field hockey players.

Antibodies, also referred to as immunoglobulins, are soluble proteins that either directly neutralise bacteria and viruses, or initiate other immune processes to eliminate these infections (Moser & Leo, 2010). Immunoglobulins are secreted by specialised immune cells known as plasma cells, and in the case of salivary SIgA, the high levels of this protective molecule are derived from plasma cells residing in mucosal tissues near to the saliva glands (Marcotte & Lavoie, 1998). While some SIgA might be specific for certain bacteria (e.g., *E. coli* – a common food contaminant) or viruses (e.g., influenza – the cause of flu), a significant proportion of SIgA is poly-reactive and is referred to as 'natural antibody' (Strugnell & Wijburg, 2010). Poly-reactive SIgA confers protection against a wide range of pathogens, therefore measuring total SIgA in saliva is an indicator of both pathogen-specific and non-specific secretory immunity (Brandtzaeg, 1998). The importance of SIgA is highlighted by examining individuals with selective IgA deficiency, a genetic disease characterised by lack of, or very low levels of IgA. These people exhibit a much higher incidence of infection than those without this genetic condition (Janzi et al., 2009).

Despite the importance of reducing infection risk in athletes, the potential impact of psychosocial factors on mucosal immunity remains unclear. Within immunological-based studies, competitive environments are often conceptualized as generally stressful events, without exploring which facets of competition are stressful (e.g., Mortatti et al., 2012). Hence, the athletic environment represents a largely untapped opportunity to study the impact of specific contextual elements and negative attitudes on individuals' well-being. For instance, the degree to which sports coaches employ maladaptive coaching practices plays a significant part in shaping athletes' experiences (Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2009). A similar picture can be observed in non-sports settings where the major focus has been on the influence of stressful life events on immune function, such as family bereavements (Goodkin et al., 1996) or stressful life roles (i.e., caring for a spouse or relative; Gallagher, Phillips, Drayson, & Carroll, 2009), rather than specific interpersonal features of the social context.

Some exceptions exist however, including evidence showing that social support is associated with higher levels of SIgA, irrespective of exposure to stressful academic exam experiences (Jemmott & Magloire, 1988). However, alternative social factors, such as loneliness and the degree of peer interaction, have shown no relationships with SIgA (Kiecolt-Glaser et al., 1984; Wawrzyniak & Pollard-Whiteman, 2011). We attempted to extend this limited knowledge base by focusing on an interpersonal factor (i.e., perceived psychological control) that has not been explored in relation to an athlete's immune function previously, despite this link holding intuitive appeal.

Psychological control refers to employing coercive, pressurising or authoritarian behaviours in order to impose a specific way of acting upon an individual (Bartholomew et al., 2009). Perceived coach psychological control has been shown to be positively correlated with thwarting of innate psychological needs, depressive symptoms, disordered eating, burnout, and negative affect in athletes (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011). Given these associations, we expect that the extent to which athletes perceive their coaches to be psychologically controlling will be associated with salivary SIgA. However, we anticipate that positive and negative relationships exist regarding within-person and between-person associations, respectively. These different processes are conceptually and statistically divergent (Curran & Bauer, 2011). Within-person changes in perceptions of control represent relatively *acute* variations around each athlete's usual perceptions, In comparison, between-person differences characterize relatively stable average (i.e., *chronic*) perceptions of coach control. Literature examining associations between stress and immunity has consistently shown that certain aspects of immune function are increased in response to acute stressors, whereas these same aspects of immunity are impaired in response to chronic stress (e.g., Bosch, Ring, de Geus, Veerman, & Amerongen, 2002). Accordingly, we propose similar relationships exist between coach psychological control and SIgA. That is, when an individual's perceptions of coach control are higher, compared to their usual perceptions (i.e., within-person increases), this will be associated with elevated SIgA levels within that individual. On the other hand, individuals with high average (chronic) perceptions of coach control will be associated with lower SIgA levels, compared to participants with low average perceptions of coach control (i.e., between-person differences).

In addition to potential interpersonal factors, many negative intrapersonal attitudes and emotions have been documented within sports settings, including burnout (Goodger, Gorely, Harwood, & Lavallee, 2007) and negative affect (Dworkin & Larson, 2006). Limited work has considered the influence of these intrapersonal states on immune function, however, in 11 professional swimmers, negative affect was positively correlated with levels of alpha amylase and chromogranin A (other anti-microbial proteins found in saliva) on the day of a competition (Diaz, Bocanegra, Teixeira, Soares, & Espindola, 2012). Similarly, the degree that athletes from a range of sports reported that their psychological needs were thwarted has also been correlated with elevated SIgA (Bartholomew et al., 2011). In contrast to the potential 'acute stressors' above, undesirable symptoms and sources of chronic stress have been negatively related to SIgA secretion rate in 15 basketball players (Moreira, Arsati, de Oliveira Lima-Arsati, Simões, & de Araújo, 2011). As a potential intrapersonal predictor of immunological response, we measured participants' intentions to drop out of the sport. Intentions to drop out have been linked with low self-determined motivation (Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002) and intrapersonal conflict (Völp & Keil, 1987), thus, we assume that holding intentions to drop out of sport represents a negative internal state that may have implications for an individual's immunological well-being. Again we mirror the conflicting relationships observed between acute and chronic stressors (Bosch et al., 2002) by proposing a positive within-person relationship and negative between-person relationship between intentions to drop out and SIgA level.

To summarize, the present study attempts to explore the novel influence of athletes' perceptions of their coach's psychological control and intentions to drop out at the end of the season on their SIgA levels. Critically, the majority of the reviewed research has examined between-person relationships among psychological factors and immune function (e.g., do individuals reporting a positive psychological profile exhibit different SIgA levels, compared to individuals reporting a negative psychological profile?). This study is the first to simultaneously disaggregate potential bidirectional effects of potential psychological predictors of immunological function by investigating within-person changes and between-person differences. In line with the bidirectional impact of chronic versus acute stressors on SIgA (Bosch et al., 2002), we hypothesize that an acute increase in an individual's perception of psychological control or intention to drop out beyond their average perceptions may be associated with elevated SIgA levels (i.e., a positive within-person relationship). In contrast, we propose that an individual experiencing higher average (chronic) levels of control or intentions to drop out may display lower SIgA levels, compared to an individual experiencing lower levels of control and intentions to drop out (i.e., a negative between-person relationship).

Materials & Methods

Participants and Procedures

Participants were 32 hockey players (21 male, 11 female; *M* age = 28 years, *SD* = 5.18, range = 18-44 years), comprising 18 participants who completed the measures at all three time points, four who completed the measures twice, and 10 who completed the measures once. The analytical strategy employed (see Data Analysis section below) allows for incomplete data to be included in the analysis (Hox, 2010). Players participated in regional leagues and competed for three different teams, each with a different coach. They trained with their respective coach for an average of 1.66 years (*SD* = 1.64), spent 3.98 (*SD* = 1.56) hours per week with the coach, and did not receive any financial income to play hockey. Finally, when asked to rate the personal importance of hockey, the average response was 5.93 on a 1-7 scale, where greater scores represent higher importance. This suggests that psychological experiences in hockey are likely to be personal meaningful.

Following approval from a university ethics committee, the study was conducted in line with APA guidelines. Data collection occurred at three time points from February to March that varied across participants but were at least one week apart (average time between time points was 15 days). A hockey season in the UK typically runs from September to March. Prior to scheduled evening training sessions (beginning at 6pm approximately), participants provided informed consent and responded to a multi-section questionnaire, taking approximately 10 minutes to complete, and provided a saliva sample for measurement of SIgA (see Measures section). Collecting saliva at the same time in the evening and prior to exercise ruled out potential confounding by diurnal variation in SIgA or acute effects of exercise (Gleeson et al., 1999).

Measures

Intention to dropout of hockey. To assess the extent to which participants were considering dropping out of hockey at the end of the season, two items used by Vallerand, Fortier, & Guay (1997) to measure school dropout were adapted to the sports context ("I often consider dropping out of this sport" and "I intend to drop out of this sport"). Despite some limitations, two items are often sufficient to represent a construct (Bollen, 1989; Marsh, Hau, Balla, & Grayson, 1998) especially when theorized as a unidimensional construct. Responses were rated on a seven-point scale ranging from 1 (*not at all true*) to 7 (*very true*).

Vallerand et al. (1997) reported adequate internal consistency of the scale and the reliability in the present study was $r = .74$.

Perceived coach control. Participants' perceptions of their coach's controlling interpersonal style were assessed using the 15-item Controlling Coach Behaviors Scale (CCBS; Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2010). The scale measures four facets of controlling coaching: controlling use of rewards (e.g., "My coach tries to motivate me by promising to reward me if I do well"), negative conditional regard (e.g., "My coach is less friendly with me if I don't make the effort to see things his/her way"), intimidation (e.g., "My coach shouts at me in front of others to make me do certain things"), and excessive personal control (e.g., "My coach expects my whole life to center on my sport participation"). These subscales were combined to reflect an overall coach control variable because we did not expect differential relationships among the different subscales of coach control and SIgA. In addition, the original scale authors have recommended using the items as an overall measure of coach control. Participants rated the degree to which they agreed with each of the items on a seven-point scale anchored by 1 (*not at all true*) and 7 (*very true*). Previous research has demonstrated acceptable internal consistency and predictive validity of the items (e.g., Bartholomew et al., 2010). The internal consistency in the present study was $\alpha = .92$.

Saliva SIgA. Participants were asked to refrain from eating, drinking, smoking or brushing their teeth for 1 hour prior to sampling and to abstain from caffeine and alcohol for 24 hours before each data collection date. Unstimulated saliva samples were collected over a 4-minute period using the passive unstimulated drool/spitting method (Navazesh, 1993). Participants were asked to collect saliva on the floor of the mouth without stimulation by oro-facial movement or swallowing, before drooling/spitting into pre-weighed polypropylene tubes at approximately 30-second intervals. Samples were weighed to assess sample volume, and stored at −20ºC until analysis. Samples were then thawed, mixed vigorously using a vortex, and centrifuged for 5 minutes at 10,000 × *g* to remove particulate matter. The supernatant was aliquoted into new tubes and SIgA measured using a commercially available enzyme-linked immuno-sorbent assay (ELISA) (Salimetrics catalog number 1-1602; PA, USA) according to the manufacturer's instructions. Intra- and inter-assay precision were 5.6% and 8.8%.

Data Analysis

Multilevel modelling was employed using MLwiN software (version 2.10; Rasbash, Browne, Healy, Cameron, & Charlton, 2012) to explore the study hypotheses. In repeated measures data sets, measurement time points are nested within study participants, which violates an assumption within many traditional single-level analyses (e.g., regression, analysis of variance) that the data are independent. Multilevel modelling overcomes this complication by constructing separate, but associated equations at both the within- and between-person levels resulting in superior estimation of the parameters and statistical significance (Hox, 2010). In addition, multilevel modelling does not require that data is collected at the same time for each participant, nor does it require the same number of responses from each participant (Hox, 2010), therefore, it has many advantages, compared to some other types of analysis.

Results

First, intercept-only models (i.e., no predictor variables included; see Table 1) were built to calculate the intraclass correlation coefficients (ICCs) of all study variables, which describe the degree of variance at the within- and between-person level of analysis. The ICCs revealed that the amount of variance attributable to the between-person level was 46% (intentions to drop out), 79% (coach control), and 7% (SIgA), respectively. Therefore, 54%, 21%, and 93% of the variance, respectively, was attributable to the within-person level of analysis. These substantial levels of variance indicate that unravelling within-person and between-person relationships among these study variables may have merit.

Next, we examined the rate of change in the three study variables across the course of the study, which took place from February to March, 2012. This was achieved by constructing unconditional growth models with a 'time' variable, which reflected the day that the data was collected (i.e., first time point = 0, last time point = 49), as a predictor in the level 1 equation. The intercept in these models referred to the average levels of the study variable at the beginning of the study and the slope coefficients reflect the amount of change across the course of the study. As shown in Table 1, average levels of intention to drop out and coach control were significantly different from zero but relatively low (1.56 and 2.20 on a 1-7 scale, respectively) and remained stable over the course of the study. Average SIgA concentration was 30.1 mg/l at the beginning of the study and increased linearly by 2.0 mg/l/day over the course of the study.

Prior to examining our primary study hypotheses, we first investigated whether a range of control variables needed to be considered in our analysis (i.e., gender, age, time elapsed since last meal) by entering them as predictors of SIgA in the multilevel regression model. SIgA was $\log^{10}$ transformed to establish normality. Results revealed that only gender significantly predicted SIgA (b = .37, p < .002) and was controlled for in subsequent models. Gender was dummy coded (0 = female, 1 = male), hence, SIgA levels were significantly higher in males, compared to females.

Next, conditional models were created by including intentions to drop out and perceived coach psychological control as predictors of SIgA in the within-person equation. Within the same models, we also included each participant's average levels of intention to drop out and perceived psychological control as predictors in the between-person equation. All variables were centred on the overall sample mean (i.e., grand mean centring), which permitted us to obtain pure estimates of the within-person and between-person associations (Marsh et al., 2012). Specifically, this strategy enabled us to conclude whether a) an increase in each participant's intention to drop out or perceptions of coach control beyond their average levels predicted higher levels of SIgA in that participant (i.e., within-person acute effects), and b) participants who reported high average intentions to drop out and/or coach control had lower concentrations of SIgA, compared to participants reporting low average intentions to drop out and/or coach control (i.e., between-person chronic effects).

As can be seen in Table 1, our within-person hypothesis was supported as changes in an individual's intention to drop out and perceived coach control were positively associated with SIgA concentration. In contrast, our between-person hypothesis received no support as no between-person associations were found among intentions to drop out, perceived coach control, and SIgA concentration, although regression coefficients were in the expected negative direction. Calculation of R_1^2 and R_2^2values indicated that inclusion of the predictors reduced the error in prediction by 23% at the within-person level and 26% at the between-person level. These values are an estimate of effect size, analogous to R^2 values in single level regression analysis (Hox, 2010).

Discussion

The present study contributes to existing knowledge by exploring the associations among perceptions of coach psychological control, intentions to drop out of sport and salivary SIgA in a sample of field hockey players. Significantly, the within-person changes and between-person differences were separated using multilevel modelling. Overall, our hypotheses proposing that an acute within-person increase in perceptions of control or intentions to drop out would be associated with elevated levels of SIgA were corroborated. However, we found no support for suppressive influences of sustained, or average, between-person levels of control or drop out intentions on SIgA.

Prior to speculating on the major findings of the study, it is worth noting the meaningful levels of variance in the study variables. Cross-sectional designs do not provide information on the decomposition of variance across within- and between-person levels of analysis, yet the findings within the present study show significant variance within individuals, especially SIgA levels. This substantiates previous evidence that employed a different statistical method to assess variability in the SIgA levels of elite yachtsman (Neville, Gleeson, & Folland, 2008). Hence, the longitudinal assessment of SIgA, as well as psychological influences, seems necessary to establish within-person and between-person variation in future scholarly work and applied athlete monitoring.

Regarding absolute levels and change in the study variables, unconditional growth models revealed that, on average the sample experienced statistically significant, albeit relatively low, levels of perceptions of control and intentions to drop out throughout the course of the study. While these low levels are encouraging, they suggest that maladaptive inter- and intrapersonal experiences were relevant in this sample. At the beginning of the study SIgA levels were relatively low compared to those reported for elite yachtsman (136mg/1; Neville et al., 2008) and sub-elite cyclists (121mg/l; Halson, Lancaster, Jeukendrup, & Gleeson, 2003). Nonetheless, the present sample displayed a linear increase in average SIgA levels over the course of the study, from approximately 30 mg/l to 128 mg/l. These increases are likely due to the linear increases in daylight across the course of the study (i.e., from February to March; Park & Tokura, 1999). Extensive differences in absolute SIgA levels between studies are, however, commonplace and can be explained by numerous factors, including between-participant variability, the characteristics (e.g., age) of the cohort, and the assay techniques employed (Shephard, 2000).

A major finding within the present study was the significant within-person association between perceptions of coach psychological control and SIgA levels. In other words, irrespective of an individual's average perceptions of the coach, a rise in feelings of being pressured, coerced, or lacking freedom to make decisions was associated with an increase in SIgA levels. This extends previous acute stress-based research (Bosch et al., 2002; Viena, Banks, Barbu, Schulman, & Tartar, 2012) by proposing that an acute within-person change in perceived maladaptive interpersonal environments is also related to elevated SIgA in saliva. More specifically, changes in experiences of psychological control seem to be of sufficient intensity to provoke changes in mucosal immunity, whereas, other stressors may not be so intense (e.g., mild academic stress; Viena et al., 2012).

Also in accordance with our hypothesis, relative (i.e., within-person) changes in individuals' negative intrapersonal attitudes, in the shape of intentions to drop out, were positively related to SIgA levels. These negative cognitions have not been linked to immune function previously, yet quitting one's sport may lead to a loss of social networks or negatively impact one's identity, therefore contemplating such an event may be detrimental to one's well-being. It is worth noting, however, that the magnitude of this relationship was smaller, compared to psychological control, suggesting that interpersonal influences may have more of an impact on SIgA than intrapersonal cognitions (see also Herbert & Cohen, 1993).

Although the mechanisms underlying our observations were not explored in this study, it is likely that intentions to drop out of sport, and perceptions of coach control, invoke feelings of acute stress. This may result in activation of the sympathetic nervous system and release of adrenaline from the adrenal medulla, both of which serve to increase secretion of salivary proteins as part of a "fight or flight" response (Bosch et al., 2002).

In contrast to the evidence regarding within-person psychosocial influences on SIgA levels, no support was found for the existence of relationships at the between-person level of analysis. That is, individuals who reported higher average levels of perceived psychological control and intentions to drop out did not display lower levels of SIgA, compared to individuals who reported lower levels of negative psychological experiences. This is somewhat surprising in view of the literature suggesting suppressive effects of various forms of chronic stress on immune function (e.g., Segerstrom & Miller, 2004). However, it is possible that the relatively low chronic levels of reported psychological control and intentions to drop out of sport may not have been sufficient to impair mucosal immunity. Alternatively, the negative experiences may be of adequate intensity but the overall amount of time spent in these hockey-based situations may not have been enough to meaningfully influence average SIgA levels. Competing at sub-elite levels may also mean that feeling controlled or intending to drop out may not be particularly meaningful and, therefore, may not have significant impact on immunity. This latter explanation is less likely, however, given the high perceived importance of field hockey reported by this cohort.

Summary and Considerations for Future Research

The fundamental message within the present study is that chronic and acute perceptions and cognitions have different associations with saliva SIgA. Corroboration of these differential relationships will have significant implications for theory and practice within sport. Hence, we suggest that other interpersonal and intrapersonal variables (e.g., autonomy support, challenge and threat appraisals) should be used in future work to see if these different associations are observed in other chronic and acute conceptual paradigms. From an applied perspective, monitoring of SIgA levels as an indicator of immunity in athletes should be conducted over a period of time using several measurements. Otherwise, certain psychological states at one point in time may artificially elevate SIgA, leading to incorrect conclusions about athletes' health. Second, while our findings do not permit firm conclusions about sustained psychologically controlling practices, the within-person associations imply that controlling coaches impact on athletes in similar ways to the effects of stress. As a result, it is recommended that practices such as controlling use of rewards, conditional regard, intimidation, and excessive personal control are minimized in coaching. Finally, practitioners often consider how external elements of the sport context (e.g., coaching, competition, extensive travel) impact upon the health of athletes, however, the findings in the present study suggest a holistic perspective is warranted towards athlete monitoring which additionally considers intrapersonal states and their influence on immunity.

Following on from the present work, subsequent studies may wish to try to explain the lack of between-person associations between the psychological factors and saliva SIgA. The regression coefficients observed in the present study were in the expected negative direction; however, the somewhat small sample at the between-person level may have contributed to the lack of statistical significant findings. Although 30 Level 2 units (i.e., participants) have been shown to be adequate for exploration of fixed effects (i.e., average relationships), larger sample sizes in future work will allow for the exploration of random effects (i.e., individual differences in the magnitude of observed relationships; Maas & Hox, 2005). A larger sample with more measurement time points will also allow for more elaborate patterns of change to be modelled and enhance the robustness of our conclusions, which were based on a modest sample size. In addition, more time points over the entire season may discount the possibility that our data collection at the end of the hockey season may have influenced the results through potentially heightened or supressed psychological states (e.g., competitions become more intense or nothing left to play for). In addition, a limitation of the present study was not controlling for non-sport factors, such as financial or relationship stressors, or the nutritional state of the athlete. Adopting a more holistic perspective in the future investigation of athletes' well-being will pinpoint the most important psychological factors for athlete health protection.

Future studies could also examine the psycho-biological mechanisms underlying the present observations. For example, the secretion of SIgA into saliva is dependent on both immune cells and glandular cells (Bosch et al., 2001; Strugnell & Wijburg, 2010). IgA is produced by plasma cells (i.e., the immune cells) in tonsillar mucosal tissue, but to enter saliva, IgA must be transported across the epithelial cells by the so-called polymeric-immunoglobulin receptor produced by glandular epithelial cells (Bosch et al., 2001; Strugnell & Wijburg, 2010). Thus, by measuring the secretory component, a part of the receptor that remains bound to SIgA after its secretion, future studies could examine whether the probable stress caused by intentions to drop out and adverse perceptions of coach control are a result of alterations that are either immune or glandular in nature.

It should also be considered that in the present study, pathogen-specific SIgA was not measured, nor were SIgA sub-types (i.e., SIgA1 and SIgA2). However, as a large proportion of SIgA is poly-reactive and is able to target a range of pathogens, the present study provides a global picture of mucosal immunity, rather than focussing on immunity towards a particular bacterial or viral infection (Strugnell & Wijburg, 2010). Further, SIgA sub-types are in approximately equal proportions in saliva (Brandtzaeg, 1998; Marcotte & Lavoie, 1998), and although SIgA1 and SIgA2 often target different pathogens (Brandtzaeg, 1998) these sub-types typically respond to physiological and psychological stressors in a similar pattern (Bosch et al., 2001).

To conclude, the present study provides novel evidence that relative within-person changes in individuals' perceptions of coach psychological control and intentions to drop out are associated with changes in salivary SIgA in field hockey players. However, between-person differences in psychological control or drop out intentions were not related to SIgA. Attempts to replicate or rebut this latter finding should be made in elite settings where the psychological experiences may have stronger implications for well-being due to greater levels of investment and stronger links to identity. Indeed, an elite sample may be more appropriate to explore influences on athletic immunity given the number of URTIs observed in elite populations (Neville et al., 2006; Robinson & Milne, 2002) and the associated implications for training and performance. Finally, studies which focus on manipulating the interpersonal environment in sport contexts are warranted to establish causal effects on SIgA levels.

References

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: the role of interpersonal control and psychological need thwarting. *Personality & Social Psychology Bulletin, 37*, 1459–1473.

Bartholomew, K. J., Ntoumanis, N., & Thøgersen-Ntoumani, C. (2009). A review of controlling motivational strategies from a self-determination theory perspective: implications for sports coaches. *International Review of Sport & Exercise Psychology, 2*, 215-233.

Bartholomew, K. J., Ntoumanis, N., & Thøgersen-Ntoumani, C. (2010). The controlling interpersonal style in a coaching context: development and initial validation of a psychometric scale. *Journal of Sport & Exercise Psychology*, *32*, 193–216.

Bollen, K. A. (1989). *Structural Equations with Latent Variables*. NY: Wiley.

Bosch, J. A., de Geus, E. J. C., Kelder, A., Veerman, E. C. I., Hoogstraten, J., & Nieuw Amerongen, A. V. (2001). Differential effects of active versus passive coping on secretory immunity. *Psychophysiology. 38*, 836-846.

Bosch, J. A., Ring, C., de Geus, E. J., Veerman, E. C., & Amerongen, A. V. (2002). Stress and secretory immunity. *International Review of Neurobiology, 52*, 213–253.

Brandtzaeg, P. (2003). Role of secretory antibodies in the defence against infections. *International Journal of Medical Microbiology*. *293*, 3–15.

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology. 62*, 583-619.

Diaz, M. M., Bocanegra, O. L., Teixeira, R. R., Soares, S. S., & Espindola, F. S. (2012). Response of salivary markers of autonomic activity to elite competition. *International Journal of Sports Medicine, 33*, 763-768.

Dworkin J., & Larson, R. (2006). Adolescents' negative experiences in organized youth activities. *Journal of Youth Development, 1*.

Fahlman, M. M., & Engels, H-J. (2005). Mucosal IgA and URTI in American college football players: A year longitudinal study. *Medicine & Science in Sports & Exercise*. *37*, 374–380.

Gallagher, S., Phillips, A. C., Drayson, M., & Carroll, D. (2009). Caregiving for children with developmental disabilities is associated with a poor antibody response to influenza vaccination. *Psychosomatic Medicine*, *71*, 341–344.

Gleeson, M., & Bishop, N. C. (2013). URI in athletes : Are mucosal immunity and cytokine responses key risk factors ? *Exercise & Sport Science Review*, *10*, 2–7.

Gleeson, M., McDonald, W. A., Pyne, D. B., Cripps, A. W., Francis, J. L., Fricker, P. A. & Clancy, R. L. (1999). Salivary IgA levels and infection risk in elite swimmers. *Medicine & Science in Sports & Exercise*. *31*, 67-73.

Goodger, K., Gorely, T., Harwood, C., & Lavallee, D. (2007). Burnout in sport: A systematic review. *The Sport Psychologist. 21*, 127-151.

Goodkin, K., Feaster, D. J., Tuttle, R., Blaney, N. T., Kumar, M., Baum, M. K., Shapshak, P., & Fletcher, M. A. (1996). Bereavement is associated with time-dependent decrements in cellular immune function in asymptomatic human immunodeficiency virus type 1-seropositive homosexual men. *Clinical & Diagnostic Laboratory Immunology*, 3, 109–118.

Halson, S. L., Lancaster, G. I., Jeukendrup, A. E., & Gleeson, M. (2003). Immunological responses to overreaching in cyclists. *Medicine & Science in Sports & Exercise, 35*, 854–861.

Herbert, T. B., & Cohen, S. (1993). Stress and immunity in humans: A meta-analytic review. *Psychosomatic Medicine, 55*, 364–379.

Hox, J. J. (2010). *Multilevel analysis: techniques and applications*, *2nd Edition*. New York: Routledge.

Janzi, M., Kull, I., Sjoberg, R., Wan, J., Melen, E., Bayat, N., Ostblom, E., Pan-Hammarstrom, Q., Nilsson, P., & Hammarstrom, L. (2009). Selective IgA deficiency in early life: Association to infections and allergic diseases during childhood. *Clinical Immunology*, *133*, 78-85.

Jemmott, J. B., & Magloire, K. (1988). Academic stress, social support, and secretory immunoglobulin A. *Journal of Personality & Social Psychology*, *55*, 803–810.

Kiecolt-Glaser, J. K., Garner, W., Speicher, C., Penn, G. M., Holliday, J., & Glaser, R. (1984). Psychosocial modifiers of immunocompetence in medical students. *Psychosomatic Medicine*, *46*, 7-14.

Maas, C. J. M & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology, 1*, 86-92. doi:10.1027/1614-1881.1.3.86

Marcotte, H., & Lavoie, M. C. (1998). Oral microbial ecology and the role of salivary immunoglobulin A. *Microbiology & Molecular Biology Review*, *62*, 71-109.

Marsh, H. W., Hau, K-T., Balla, J. R., & Grayson, D. (1998) Is more ever too much? The number of indicators per factor in confirmatory factor analysis. *Multivariate Behavioral Research, 33*, 181-220.

Marsh, H. W., Lüdtke, O., Nagengast, B., Trautwein, U., Morin, A. J. S., Abduljabbar, A. S., & Koller, O. (2012). Classroom climate and contextual Effects: Conceptual and methodological issues in the evaluation of group-level effects. *Educational Psychologist, 47*, 106-124.

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., & Urhausen, A. (2013). Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport

Science (ECSS) and the American College of Sports Medicine (ACSM). *European Journal of Sport Science, 13*, 1-24.

Moreira, A., Arsati, F., de Oliveira Lima-Arsati, Y. B., Simões, A. C., & de Araújo, V. C. (2011). Monitoring stress tolerance and occurrences of upper respiratory illness in basketball players by means of psychometric tools and salivary biomarkers. *Stress & Health*, *27*, e166–e172.

Mortatti, A. L., Moreira, A., Aoki, M. S., Crewther, B. T., Castagna, C., de Arruda, A. F. S., & Filho, J. M. (2012). Effect of competition on salivary cortisol, immunoglobulin A, and upper respiratory tract infections in elite young soccer players. *Journal of Strength & Conditioning Research, 26*, 1396-1401.

Moser, M., & Leo, O. (2010). Key concepts in immunology. *Vaccine, 28*, C2-C13.

Navazesh, M. (1993). Methods for collecting saliva. *Annals of the New York Academy of Sciences, 694*, 72-77.

Neville, V., Gleeson, M., & Folland, J. P. (2008). Salivary IgA as a risk factor for upper respiratory infections in elite professional athletes. *Medicine & Science in Sports & Exercise, 40*, 1228–1236.

Neville, V., Molloy, J., Brooks, J., Speedy, D., & Atkinson, G. (2006). Epidemiology of injuries and illness in America's Cup yacht racing. *British Journal of Sports Medicine, 40,* 304-311.

Park, S. J., & Tokura, H. (1999). Bright light exposure during the daytime affects circadian rhythms of urinary melatonin and salivary immunoglobulin A. *Chronobiology International*, *16*, 359-371.

Rasbash, J., Browne, W. J., Healy, M., Cameron, B., & Charlton, C. M. J. (2012). *MLwiN Version 2.25*.

Robinson, D., & Milne, C. (2002). Medicine at the 2000 Sydney Olympic Games: the New Zealand health team. *British Journal of Sports Medicine*, *36*, 229.

Sarrazin, P., Vallerand, R., Guillet, E., Pelletier, L., & Cury, F. (2002). Motivation and dropout in female handballers: a 21-month prospective study. *European Journal of Social Psychology*, *32*, 395-418.

Segerstrom, S. C., & Miller, G. E. (2004). Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry. *Psychological Bulletin, 130*, 601-630.

Shephard, R. J. (2000). Special feature for the Olympics: Effects of exercise on the immune system: Overview of the epidemiology of exercise immunology. *Immunology Cell Biology. 78*, 485–495.

Strugnell, R. A., & Wijburg, O. L. C. (2010). The role of secretory antibodies in infection immunity. *Nature Reviews Microbiology. 8,* 656-667.

Valdimarsdottir, H. B., & Stone, A. A. (1997). Psychosocial factors and secretory immunoglobulin A. *Critical Reviews in Oral Biology. 8,* 461–474.

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: Toward a motivational model of high school dropout. *Journal of Personality & Social Psychology, 72,* 1161-1176.

Viena, T. D., Banks, J. B., Barbu, I. M., Schulman, A. H., & Tartar, J. L. (2012). Differential effects of mild chronic stress on cortisol and S-IgA responses to an acute stressor. *Biological Psychol*ogy*, 91,* 307–311.

Völp, A., & Keil, U. (1987). The relationship between performance, intention to drop out, and interpersonal conflict in swimmers. *Journal of Sport Psychology. 9*, 358-375.

Wawrzyniak, A. J., & Whiteman, M. C. P. (2011). Perceived stress, loneliness, and interaction with fellow students does not affect innate mucosal immunity in first year university students. *Japanese Psychological Research, 53*, 121–132.

Table 1

Multilevel models exploring variability and change in study variables and predictors of SIgA.

	Outcome Variable						
	Intercept only models			Unconditional growth models			Conditional model
Predictor Variables	Coach Control	Drop out intentions	SIgA	Coach Control	Drop out intentions	SIgA	SIgA
Fixed effects							
Intercept	2.30**	1.92**	84.40**	2.20**	1.56**	30.09	1.49**
Time				0.00	0.01	2.01**	
Gender							0.33**
Within-person coach control							0.27*
Within-person drop out intentions							0.13*
Between-person coach control							-0.20
Between-person drop out intentions							-0.12
Random effects							
Level 1 residual variance	0.14**	0.92**	7152.71**	0.13**	0.86**	5450.54**	0.08**
Level 2 residual variance	0.54**	0.79*	525.77	0.54**	0.86*	1951.60	0.05*

Note. * $p < .05$, ** $p < .01$